

WHAT IS CLAIMED IS:

1        1.        A method of improving etch selectivity of silicon nitride relative to an adjacent  
2        patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3        of said patterned organic DUV photoresist with plasma species generated from a plasma  
4        source gas consisting essentially of at least one inorganic fluorine-comprising gas and sulfur  
5        dioxide (SO<sub>2</sub>), wherein the molecular ratio of said inorganic fluorine-comprising gas to said  
6        sulfur dioxide ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist  
7        surface, whereby the etch rate of said organic DUV photoresist is slowed, while said silicon  
8        nitride exposed through said patterned organic DUV photoresist is etched.

1        2.        The method of Claim 1, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2        said plasma source gas is varied during said etching of said silicon nitride.

1        3.        The method of Claim 1, wherein one of said at least one inorganic fluorine-  
2        comprising gases is sulfur hexafluoride (SF<sub>6</sub>).

1        4.        The method of Claim 1, wherein one of said at least one inorganic fluorine-  
2        comprising gases is nitrogen trifluoride (NF<sub>3</sub>).

1        5.        The method of Claim 1, wherein said plasma source gas includes two inorganic  
2        fluorine-comprising gases.

1        6.        The method of Claim 1, wherein a temperature of a substrate which includes said  
2        silicon nitride is between about 20°C and 100°C during exposure to said plasma etchant.

1 7. The method of Claim 6, wherein said temperature is between about 40°C and  
2 60°C.

1 8. The method of Claim 1, wherein said silicon nitride etch rate is at least two times  
2 said organic DUV photoresist etch rate.

1 9. The method of Claim 1, wherein said patterned organic DUV photoresist has a  
2 thickness of less than about 4000 Å.

1 10. The method of Claim 1, wherein said exposing of the structure comprising said  
2 silicon nitride and said patterned organic DUV photoresist to said plasma etchant results in  
3 an etched inorganic substrate having a feature size less than 2500 Å.

1 11. The method of Claim 1, wherein said selectivity of said silicon nitride relative to  
2 said adjacent patterned organic DUV photoresist is greater than 1.5.

1 12. The method of Claim 11, wherein said selectivity is greater than about 2.0.

1 13. The method of Claim 1, wherein said plasma etchant is generated from a high  
2 density plasma.

1 14. The method of Claim 13, wherein said plasma density is at least  $10^{11}$  e<sup>-</sup>/cm<sup>3</sup>.

1 15. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma

4 source gas consisting essentially of at least one inorganic fluorine-comprising gas, sulfur  
5 dioxide (SO<sub>2</sub>), and a diluent gas selected from the group consisting of Ar, Kr, Xe, and He,  
6 wherein the molecular ratio of said inorganic fluorine-comprising gas to said sulfur dioxide  
7 ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface,  
8 whereby the etch rate of said organic DUV photoresist is slowed, while said silicon nitride  
9 exposed through said patterned organic DUV photoresist is etched.

1 16. The method of Claim 15, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 17. The method of Claim 15, wherein a molecular ratio of said inorganic fluorine-  
2 comprising gas to said diluent gas ranges from about 0.1 : 1 to about 10 : 1.

1 18. The method of Claim 15, wherein said diluent gas is argon (Ar).

1 19. The method of Claim 15, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 20. The method of Claim 19, wherein said sulfur dioxide amount is about 10% -15%  
2 by volume of said plasma source gas.

1 21. The method of Claim 15, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 20% - 60% by volume of said plasma source gas.

1 22. The method of Claim 21, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 25% - 35% by volume of said plasma source gas.

1 23. The method of Claim 18, wherein said argon amount is about 20% - 60% by  
2 volume of said plasma source gas.

1 24. The method of Claim 23, wherein said argon amount is about 50% - 60% by  
2 volume of said plasma source gas.

1 25. The method of Claim 15, wherein one of said at least one inorganic fluorine-  
2 comprising gases is sulfur hexafluoride (SF<sub>6</sub>).

1 26. The method of Claim 15, wherein one of said at least one inorganic fluorine-  
2 comprising gases is nitrogen trifluoride (NF<sub>3</sub>).

1 27. The method of Claim 15, wherein said plasma source gas includes two inorganic  
2 fluorine-comprising gases.

1 28. The method of Claim 27, wherein a total amount of said inorganic fluorine-  
2 comprising gases is about 20% - 60% by volume of the plasma source gas.

1 29. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of at least one inorganic fluorine-comprising gas, sulfur  
5 dioxide (SO<sub>2</sub>), and hydrogen bromide (HBr), wherein the molecular ratio of said inorganic  
6 fluorine-comprising gas to said sulfur dioxide ranges from about 50 : 1 to about 1 : 1, to  
7 produce a reacted DUV photoresist surface, whereby the etch rate of said organic DUV

8 photoresist is slowed, while said silicon nitride exposed through said patterned organic DUV  
9 photoresist is etched.

1 30. The method of Claim 29, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 31. The method of Claim 29, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 32. The method of Claim 31, wherein said sulfur dioxide amount is about 10% - 15%  
2 by volume of said plasma source gas.

1 33. The method of Claim 29, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 20% - 60% by volume of said plasma source gas.

1 34. The method of Claim 33, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 25% - 35% by volume of said plasma source gas.

1 35. The method of Claim 29, wherein said hydrogen bromide amount is about  
2 10% - 60% by volume of said plasma source gas.

1 36. The method of Claim 35, wherein said hydrogen bromide amount is about  
2 20% - 40% by volume of said plasma source gas.

1 37. The method of Claim 29, wherein one of said at least one inorganic fluorine-  
2 comprising gases is sulfur hexafluoride (SF<sub>6</sub>).

1 38. The method of Claim 29, wherein one of said at least one inorganic fluorine-  
2 comprising gases is nitrogen trifluoride (NF<sub>3</sub>).

1 39. The method of Claim 29, wherein said plasma source gas includes two inorganic  
2 fluorine-comprising gases.

1 40. The method of Claim 39, wherein a total amount of said inorganic fluorine-  
2 comprising gases is about 20% - 60% by volume of the plasma source gas.

1 41. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of at least one inorganic fluorine-comprising gas, sulfur  
5 dioxide (SO<sub>2</sub>), hydrogen bromide (HBr), and a diluent gas selected from the group  
6 consisting of Ar, Kr, Xe, and He, wherein the molecular ratio of said inorganic fluorine-  
7 comprising gas to said sulfur dioxide ranges from about 50 : 1 to about 1 : 1, to produce a  
8 reacted DUV photoresist surface, whereby the etch rate of said organic DUV photoresist is  
9 slowed, while said silicon nitride exposed through said patterned organic DUV photoresist  
10 is etched.

1 42. The method of Claim 41, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 43. The method of Claim 41, wherein a molecular ratio of said inorganic fluorine-  
2 comprising gas to said diluent gas ranges from about 0.1 : 1 to about 10 : 1.

1 44. The method of Claim 41, wherein said diluent gas is argon (Ar).

1 45. The method of Claim 41, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 46. The method of Claim 45, wherein said sulfur dioxide amount is about 10% -15%  
2 by volume of said plasma source gas.

1 47. The method of Claim 41, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 20% - 60% by volume of said plasma source gas.

1 48. The method of Claim 47, wherein said at least one inorganic fluorine-comprising  
2 gas amount is about 25% - 35% by volume of said plasma source gas.

1 49. The method of Claim 41, wherein said hydrogen bromide amount is about  
2 10% - 60% by volume of said plasma source gas.

1 50. The method of Claim 49, wherein said hydrogen bromide amount is about  
2 20% - 40% by volume of said plasma source gas.

1 51. The method of Claim 44, wherein said argon amount is about 20% - 60% by  
2 volume of said plasma source gas.

1 52. The method of Claim 51, wherein said argon amount is about 50% - 60% by  
2 volume of said plasma source gas.



1 53. The method of Claim 41, wherein one of said at least one inorganic fluorine-  
2 comprising gases is sulfur hexafluoride (SF<sub>6</sub>).

1 54. The method of Claim 41, wherein one of said at least one inorganic fluorine-  
2 comprising gases is nitrogen trifluoride (NF<sub>3</sub>).

1 55. The method of Claim 41, wherein said plasma source gas includes two inorganic  
2 fluorine-comprising gases.

1 56. The method of Claim 55, wherein a total amount of said inorganic fluorine-  
2 comprising gases is about 20% - 60% by volume of the plasma source gas.

1 57. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of sulfur hexafluoride (SF<sub>6</sub>) and sulfur dioxide (SO<sub>2</sub>),  
5 wherein the molecular ratio of said sulfur hexafluoride to said sulfur dioxide ranges from  
6 about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface, whereby the etch  
7 rate of said organic DUV photoresist is slowed, while said silicon nitride exposed through  
8 said patterned organic DUV photoresist is etched.

1 58. The method of Claim 57, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.



1 59. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of sulfur hexafluoride ( $\text{SF}_6$ ), sulfur dioxide ( $\text{SO}_2$ ), and  
5 argon (Ar), wherein the molecular ratio of said sulfur hexafluoride to said sulfur dioxide  
6 ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface,  
7 whereby the etch rate of said organic DUV photoresist is slowed, while said silicon nitride  
8 exposed through said patterned organic DUV photoresist is etched.

1 60. The method of Claim 59, wherein the amount of sulfur dioxide ( $\text{SO}_2$ ) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 61. The method of Claim 59, wherein a molecular ratio of said sulfur hexafluoride  
2 to said argon ranges from about 0.1 : 1 to about 10 : 1.

1 62. The method of Claim 59, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 63. The method of Claim 62, wherein said sulfur dioxide amount is about 10% - 15%  
2 by volume of said plasma source gas.

1 64. The method of Claim 59, wherein said sulfur hexafluoride amount is about 20% -  
2 60% by volume of said plasma source gas.

1 65. The method of Claim 64, wherein said sulfur hexafluoride amount is about 25% -  
2 35% by volume of said plasma source gas.

1 66. The method of Claim 59, wherein said argon amount is about 20% - 60% by  
2 volume of said plasma source gas.

1 67. The method of Claim 66, wherein said argon amount is about 50% - 60% by  
2 volume of said plasma source gas.

1 68. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of sulfur hexafluoride ( $\text{SF}_6$ ), sulfur dioxide ( $\text{SO}_2$ ), and  
5 hydrogen bromide ( $\text{HBr}$ ), wherein the molecular ratio of said inorganic fluorine-comprising  
6 gas to said sulfur dioxide ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV  
7 photoresist surface, whereby the etch rate of said organic DUV photoresist is slowed, while  
8 said silicon nitride exposed through said patterned organic DUV photoresist is etched.

1 69. The method of Claim 68, wherein the amount of sulfur dioxide ( $\text{SO}_2$ ) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 70. The method of Claim 68, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 71. The method of Claim 70, wherein said sulfur dioxide amount is about 10% - 15%  
2 by volume of said plasma source gas.

1 72. The method of Claim 68, wherein said sulfur hexafluoride amount is about  
2 20% - 60% by volume of said plasma source gas.

1 73. The method of Claim 72, wherein said sulfur hexafluoride amount is about  
2 25% - 35% by volume of said plasma source gas.

1 74. The method of Claim 68, wherein said hydrogen bromide amount is about  
2 10% - 60% by volume of said plasma source gas.

1 75. The method of Claim 74, wherein said hydrogen bromide amount is about  
2 20% - 40% by volume of said plasma source gas.

1 76. A method of improving etch selectivity of silicon nitride relative to an adjacent  
2 patterned organic DUV photoresist during plasma etching, comprising: reacting a surface  
3 of said patterned organic DUV photoresist with plasma species generated from a plasma  
4 source gas consisting essentially of sulfur hexafluoride (SF<sub>6</sub>), sulfur dioxide (SO<sub>2</sub>), hydrogen  
5 bromide (HBr), and a diluent gas selected from the group consisting of Ar, Kr, Xe, and He,  
6 wherein the molecular ratio of said inorganic fluorine-comprising gas to said sulfur dioxide  
7 ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface,  
8 whereby the etch rate of said organic DUV photoresist is slowed, while said silicon nitride  
9 exposed through said patterned organic DUV photoresist is etched.

1 77. The method of Claim 76, wherein the amount of sulfur dioxide (SO<sub>2</sub>) present in  
2 said plasma source gas is varied during said etching of said silicon nitride.

1 78. The method of Claim 76, wherein a molecular ratio of said inorganic fluorine-  
2 comprising gas to said diluent gas ranges from about 0.1 : 1 to about 10 : 1.

1 79. The method of Claim 76, wherein said diluent gas is argon (Ar).

1 80. The method of Claim 76, wherein said sulfur dioxide amount is about 2% - 20%  
2 by volume of said plasma source gas.

1 81. The method of Claim 80, wherein said sulfur dioxide amount is about 10% -15%  
2 by volume of said plasma source gas.

1 82. The method of Claim 76, wherein said sulfur hexafluoride amount is about  
2 20% - 60% by volume of said plasma source gas.

1 83. The method of Claim 82, wherein said sulfur hexafluoride amount is about  
2 25% - 35% by volume of said plasma source gas.

1 84. The method of Claim 76, wherein said hydrogen bromide amount is about  
2 10% - 60% by volume of said plasma source gas.

1 85. The method of Claim 84, wherein said hydrogen bromide amount is about  
2 20% - 40% by volume of said plasma source gas.

1 86. The method of Claim 79, wherein said argon amount is about 20% - 60% by  
2 volume of said plasma source gas.

- 1 87. The method of Claim 86, wherein said argon amount is about 50% - 60% by
- 2 volume of said plasma source gas.